

HERRENKNECHT



Tunnelling Systems

HERRENKNECHT AG

TUNNELLING AND TRENCHLESS SOLUTIONS FOR HARD ROCK

**ROOM FOR TBM TUNNELS - HOW SMALL? HOW LONG?
WHICH TECHNOLOGY? ENERGY CONSUMPTION?
CEMENT CONSUMPTION?"**

Trondheim, Thursday 9th of January 2025

HERRENKNECHT FULL RANGE SOLUTIONS

H+E
LOGISTIK



VMT



EUROFORM



HERRENKNECHT
FORMWORK



HERRENKNECHT
SEPARATIONS



TECHNI-MÉTAL
SYSTÈMES



GLOBAL
TUNNELLING
EXPERTS



CONTROL CENTER & DATA MANAGEMENT

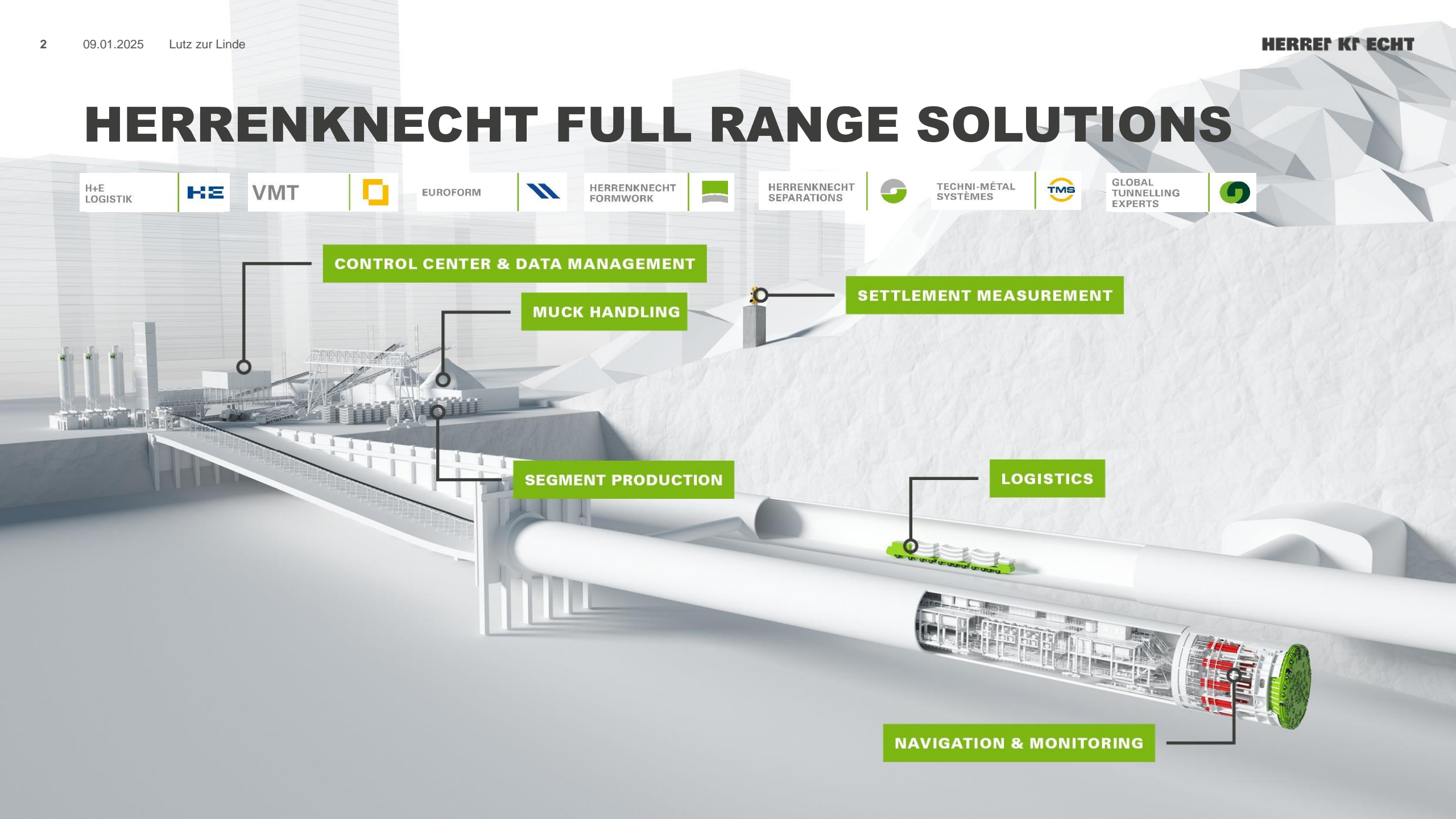
MUCK HANDLING

SETTLEMENT MEASUREMENT

SEGMENT PRODUCTION

LOGISTICS

NAVIGATION & MONITORING



Number of tunnelling machines for international projects

HERRENKNECHT TUNNELLING EQUIPMENT

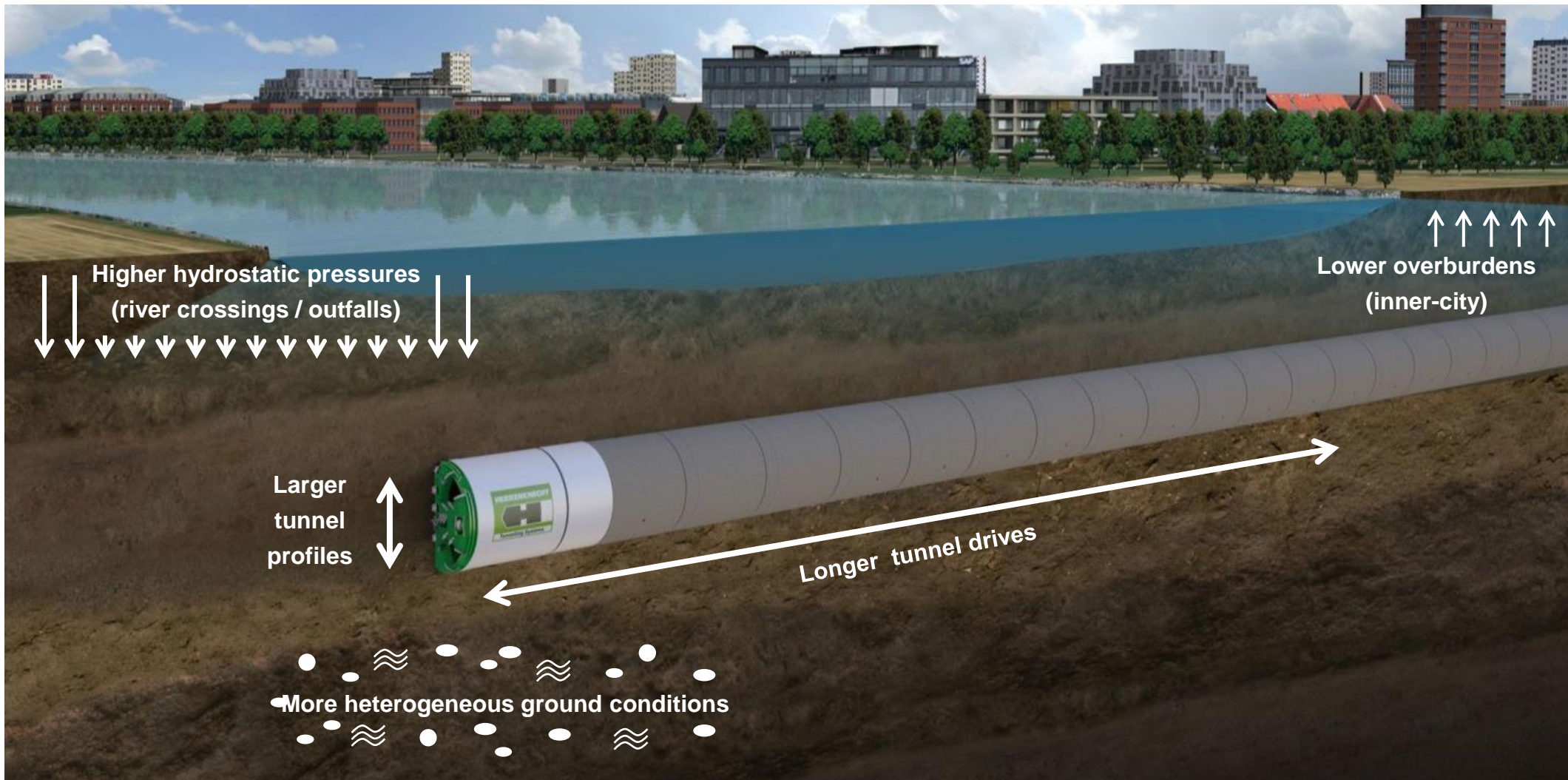
DESIGNED. BUILT. DELIVERED. SINCE 1977.

> 1400 TBMs for Traffic Tunnels

A 3D architectural rendering of a city street with a large tunnel boring machine (TBM) cutting through it. The TBM is shown in a cross-section, revealing its internal components and the tunnel it is creating. The street is filled with buildings and pipes, and the TBM is shown in the process of cutting through the ground. A smaller inset image shows a utility tunneling machine (TBM) cutting through a utility tunnel.

> 2500 TBMs for Utility Tunnels

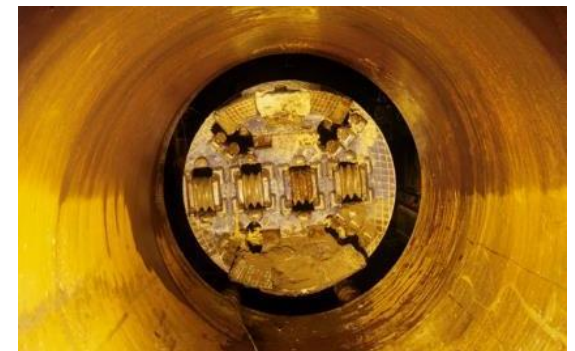
GENERAL TRENDS IN TUNNELLING



Utility Tunnelling

TRENDS & CHALLENGES IN PIPE JACKING

- › Deep alignments | high groundwater pressure
- › Occupied space | utilities beneath cities
- › **Longer drives**
- › **Changing / mixed ground & hard rock conditions**
- › Shallow alignments | relatively small diameters
- › **Steep alignments | tight curves**
- › Hard and abrasive rock
- › **Blindhole applications** | wet recovery for lake and ocean outfalls
- › River crossings with permeable soils (Direct Pipe)
- › Low permeability/stickiness (Material transport)
- › High permeability (tunnel face stability, frac-out risk)



Crucial for selection of appropriate machine concept

GEOTECHNICAL DATA

PRESTUDY

**GROUND
CONDITIONS
&
HYDROLOGY**

DESIGN AND PLANNING OF...

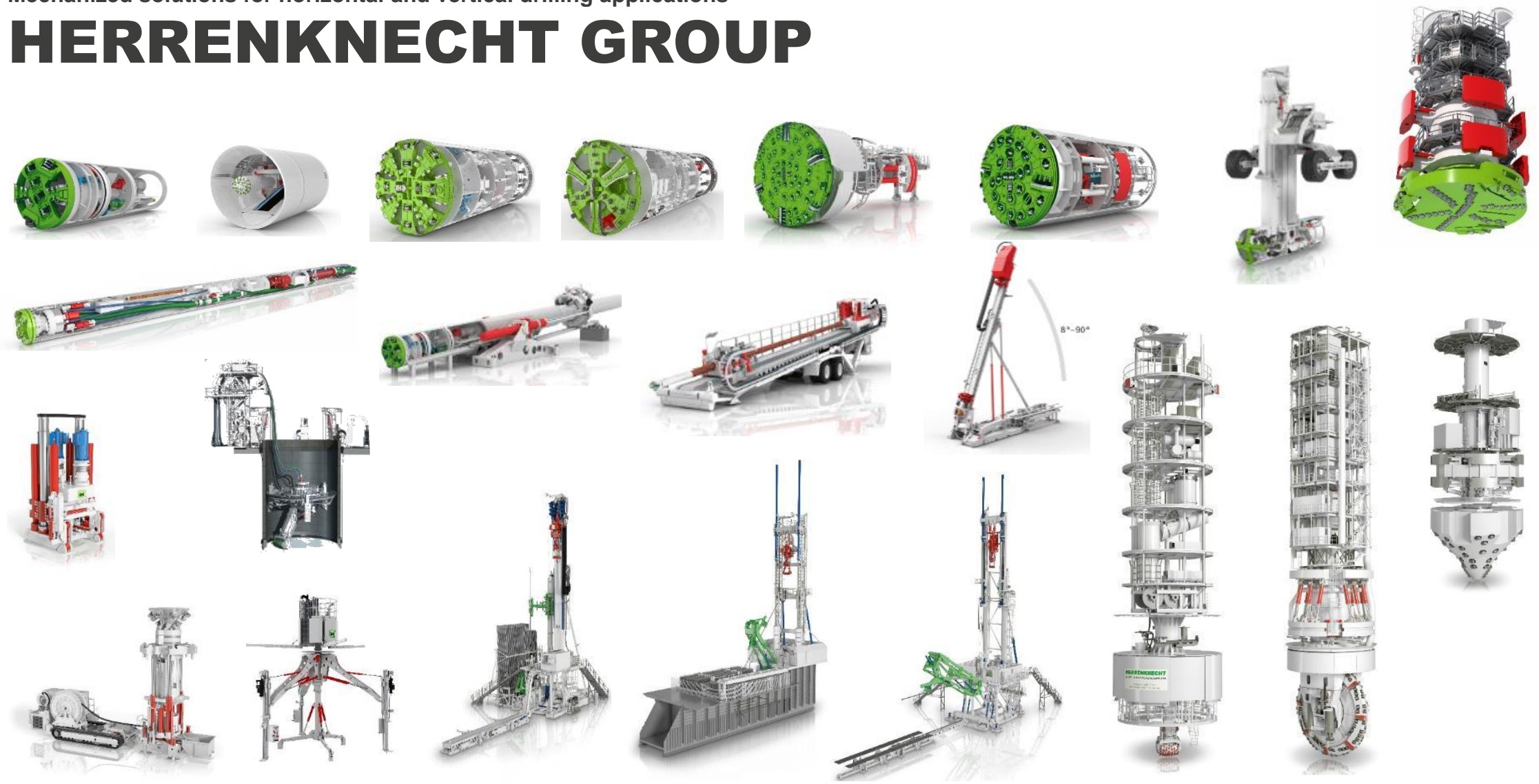
- ✓ tunnel alignment (overburden, gradient, curves,...)
- ✓ groundwater handling
- ✓ tunnel face support
- ✓ face support medium
- ✓ soil bearing capacity
- ✓ soil conditioning
- ✓ handling of boulders
- ✓ soil disposal

SELECTION

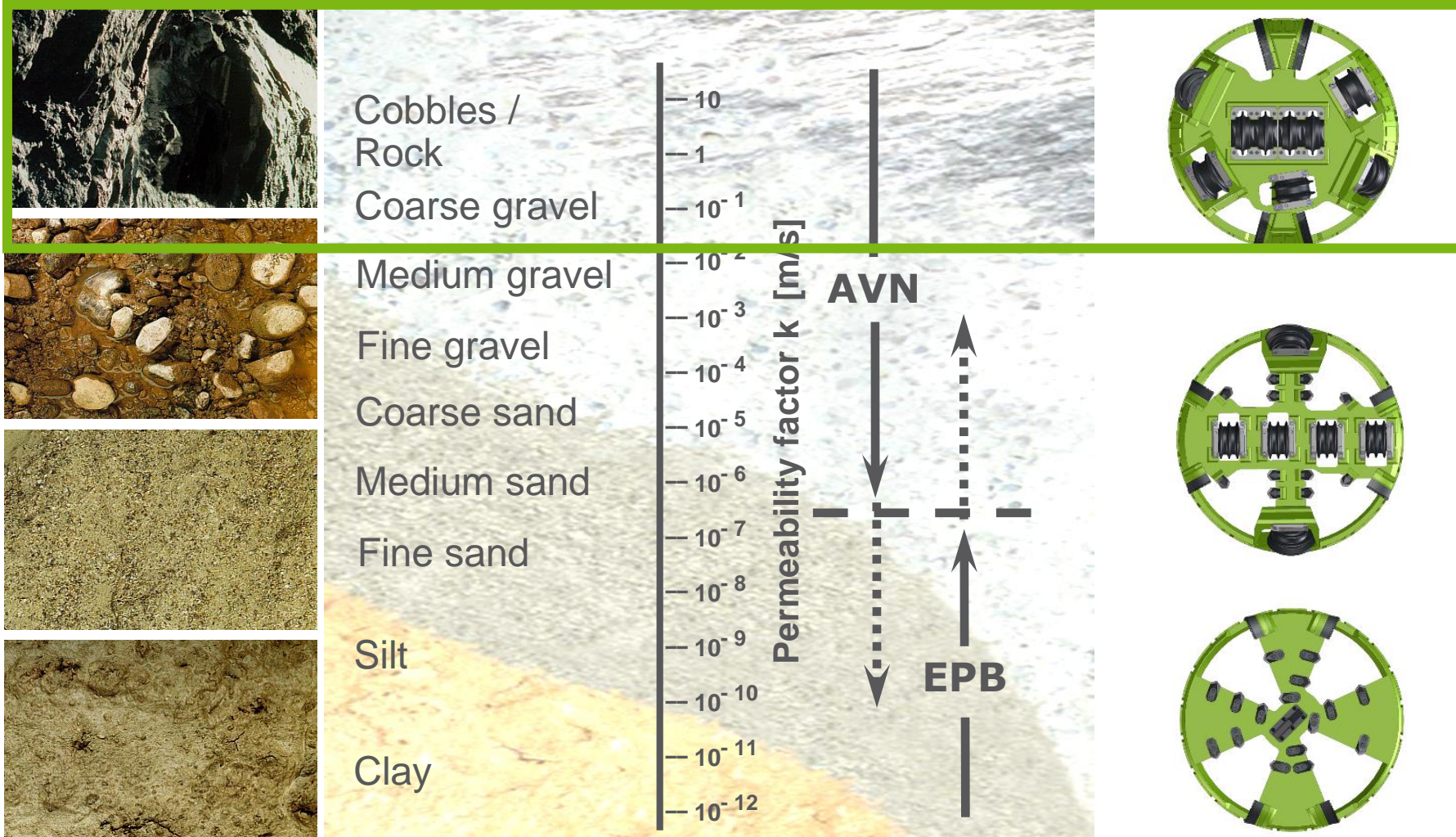
**TUNNELLING
TECHNOLOGY
&
MACHINE
CONCEPT**

Mechanized solutions for horizontal and vertical drilling applications

HERRENKNECHT GROUP

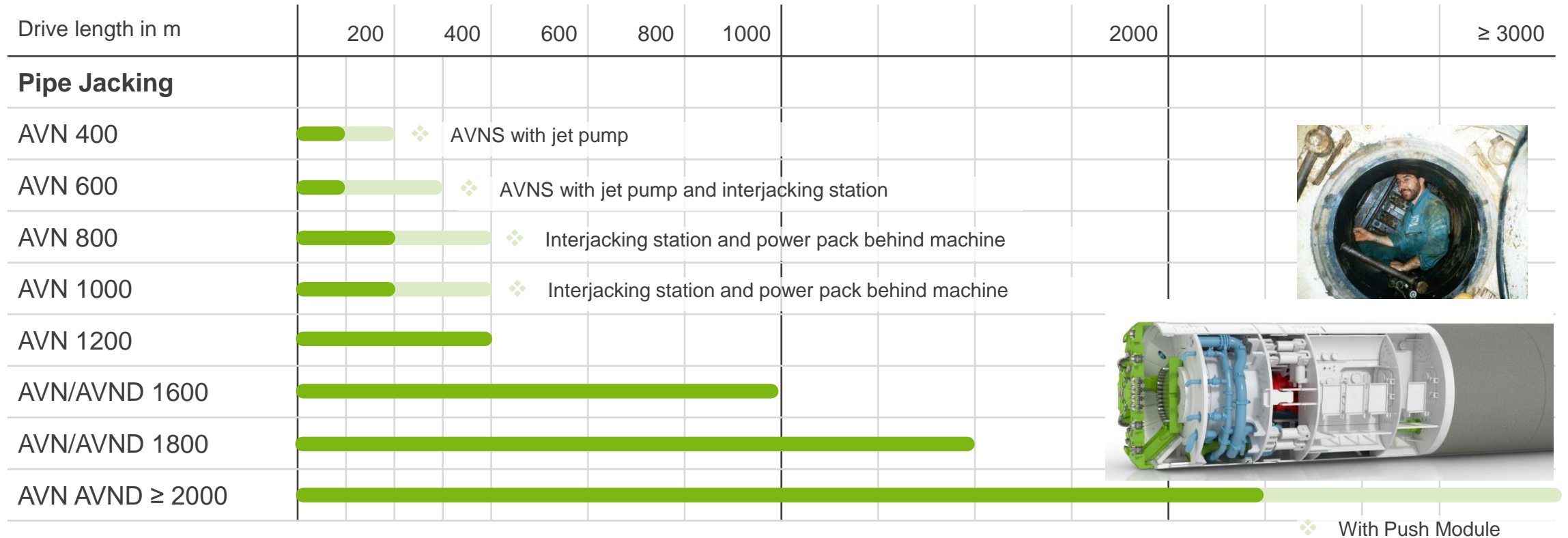


PIPE JACKING IN HARD ROCK



Pipe Jacking

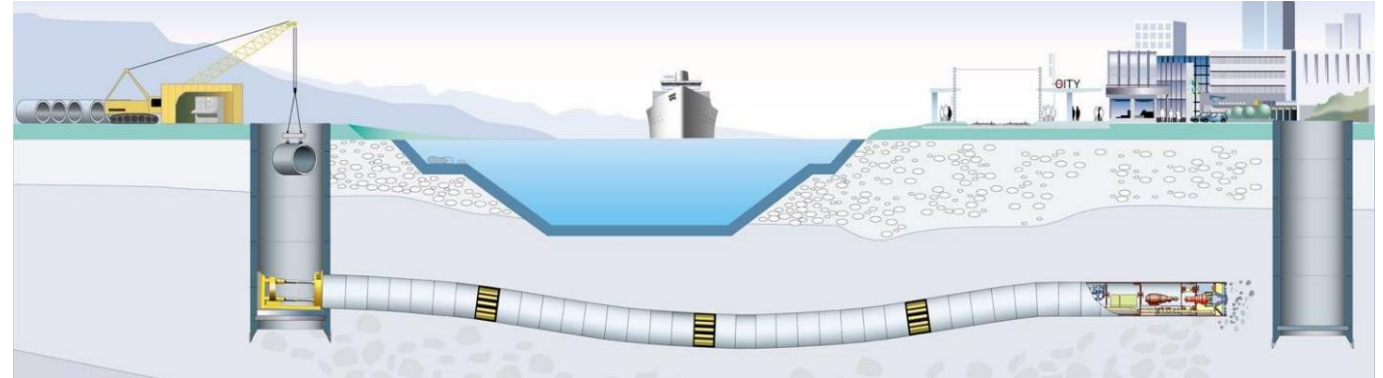
DIAMETERS AND DRIVE LENGTH



› These drive lengths are rough indications, as feasibility depends on specific ground and project conditions!

XXL Pipe Jacking

LONG-DISTANCE PIPE JACKING



- More than **110 long-distance projects** \geq **1000 m** since early 1990s.
- **> 90% with Slurry** machines

2,535 m, Germany

- Europipe, OD 3820 mm



2,246 m, Mexico

- Altamira landfall, OD 3200 mm



1,960 m, Kuwait

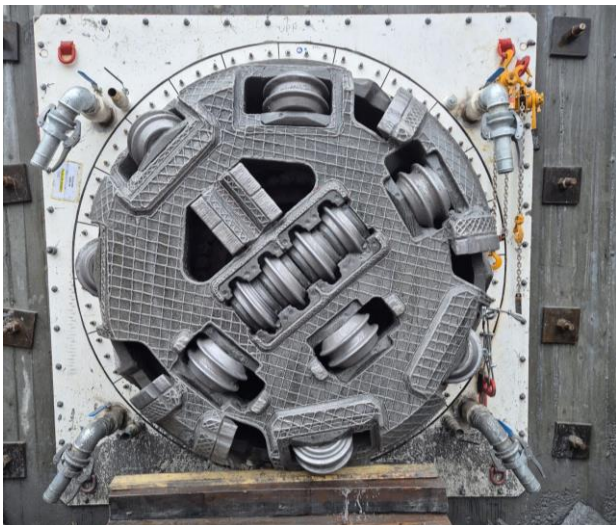
- WWTP Outfall, OD 2665 mm



Pipe jacking reference Project in Norway

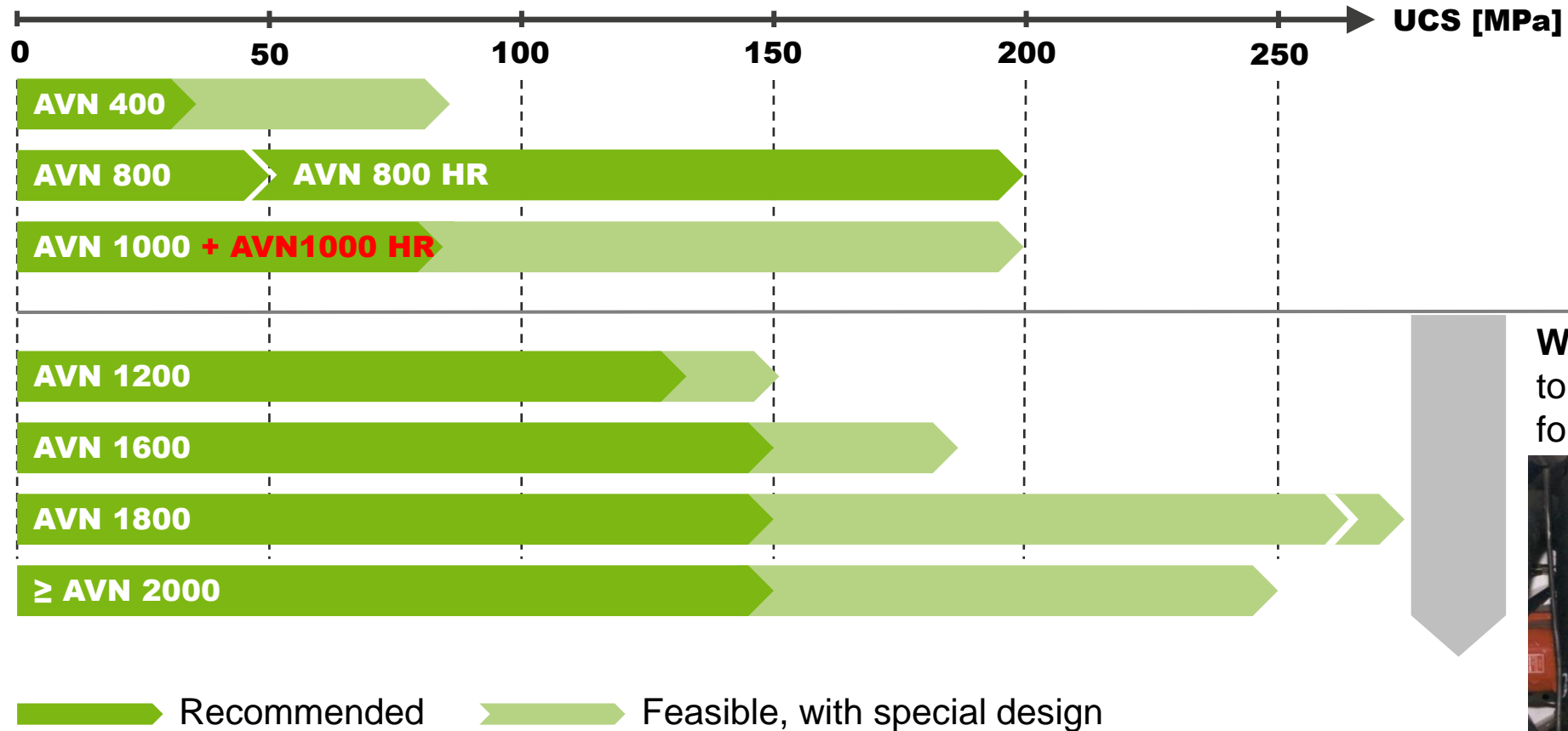
MICROTUNNELLING IN HARD ROCK IN OSLO, LYSAKER

- › M-2190M, AVN1600TB – Highway Crossing E18
- › Drive Length: 2 x L= 57 m
- › Geology: Slate or Shale rock with limestone rock and Syenite Porphyry- Rock max. UCS: 80-100 MPa
- › Contractor: BAB Rörtryckning AB / SKANSKA
- › Ostersund:



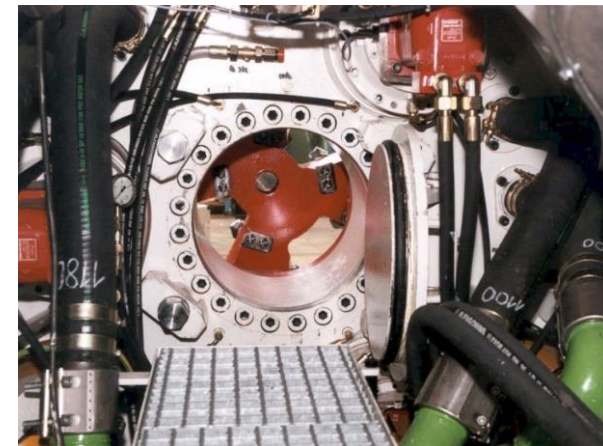
Recommended application range in respective hard rock conditions

AVN MACHINE RANGE FOR SLURRY PIPE JACKING IN HARD ROCK



➤ **A2 Cholupice, Praha**
➤ AVN800 / Rock Cutting Head






With access
to excavation chamber
for tool change

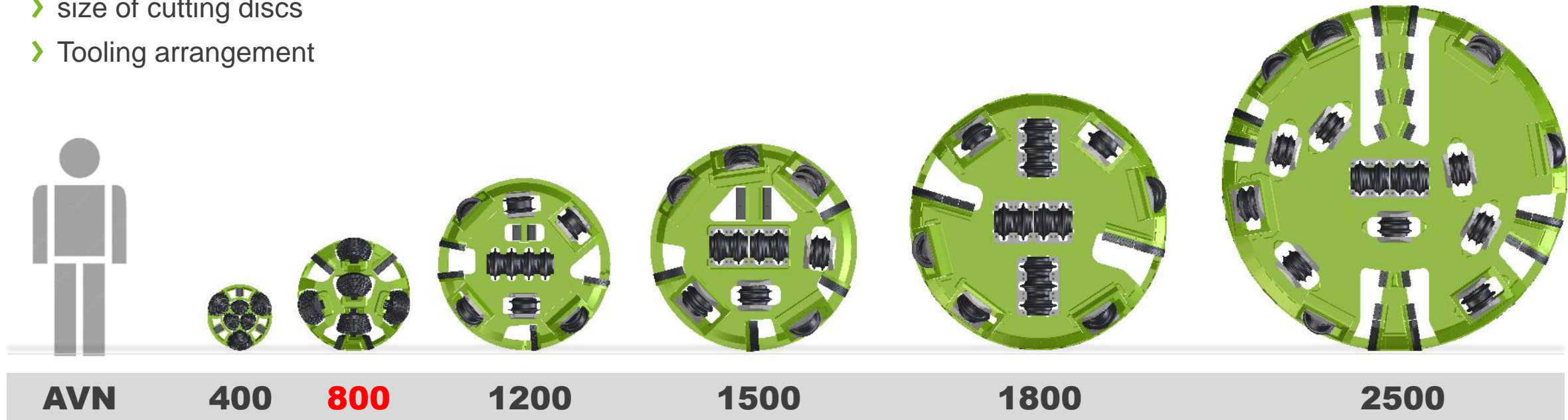


Cutting wheel design

MTBM TECHNOLOGY FOR HARD ROCK CONDITIONS

- › Equipped with cutting discs and reamers
- › Increasing flexibility for tooling with increase of MTBM diameter regarding:
 - › amount of cutting discs
 - › size of cutting discs
 - › Tooling arrangement

Disc Cutter RING VERSION (1/2-ring)	Disc Cutter MONOBLOCK (1/2/3-ring)	Disc Cutter HARD FACING (1/2/3-ring; opt. TCI inserts)	TCI CUTTER (opt. hard facing)	MILLED TOOTH CUTTER
				



AVN 800 HR

Special design for hard rock conditions



AVN 800 for hard rock

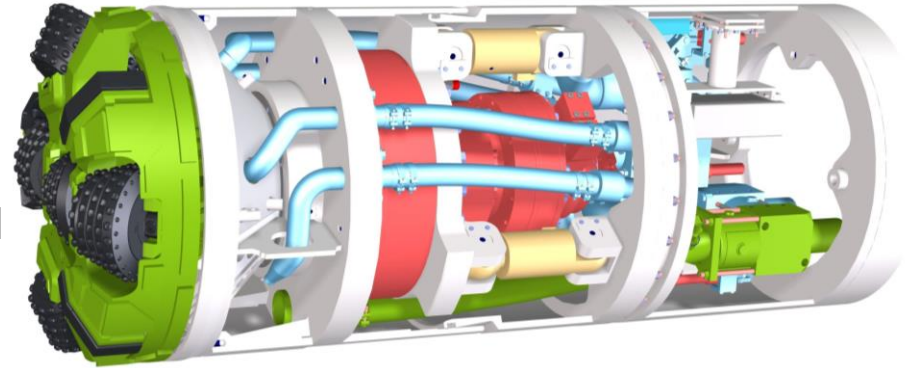
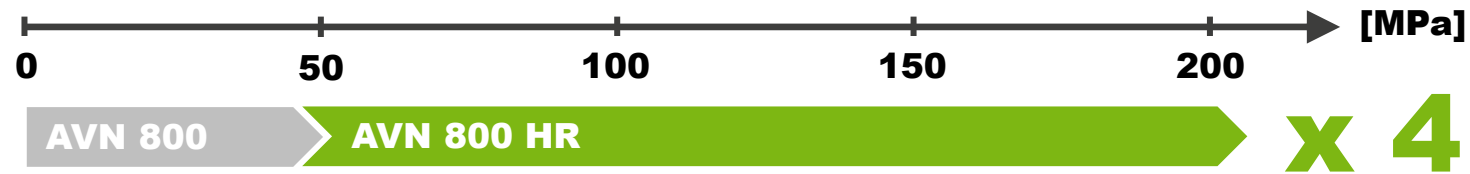
Cutting wheel design with 5 TCI cutters

- › Punctual impact of TCI cutters to produce small, transportable rock chips
- › Highly wear-resistant TCI Discs
- › Extra stronger bearing: 89 to. | 890 kN (3x more)
- › High rotation speed for high advance rates possible (26rpm)

Special design for hard rock conditions

AVN 800 HR

Unconfined compressive strength (UCS)



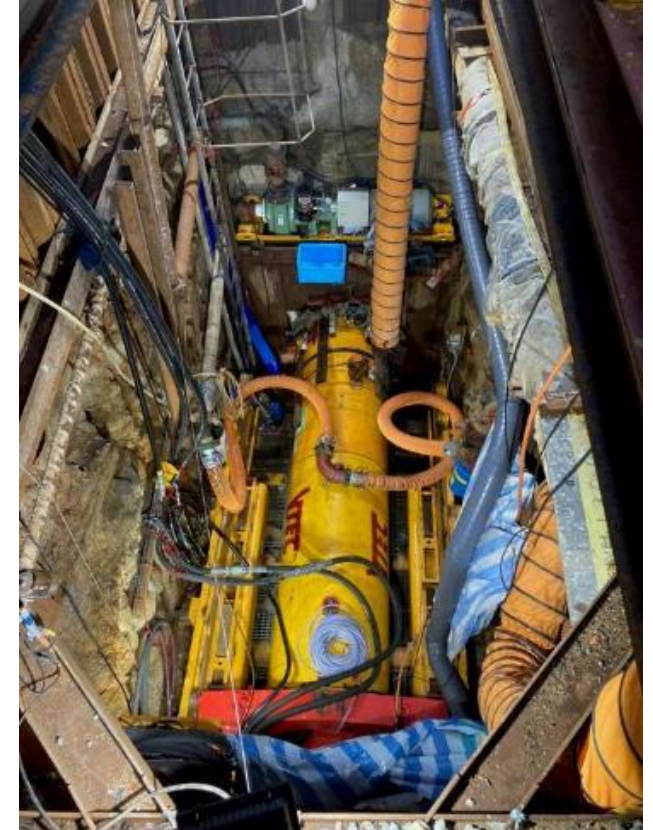
Drive length in hard rock



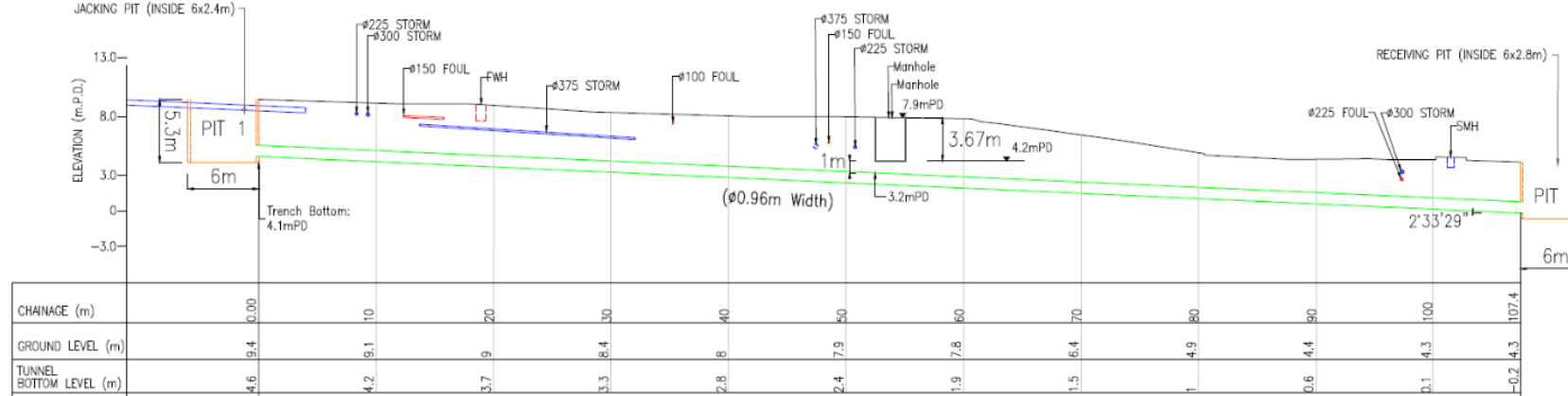
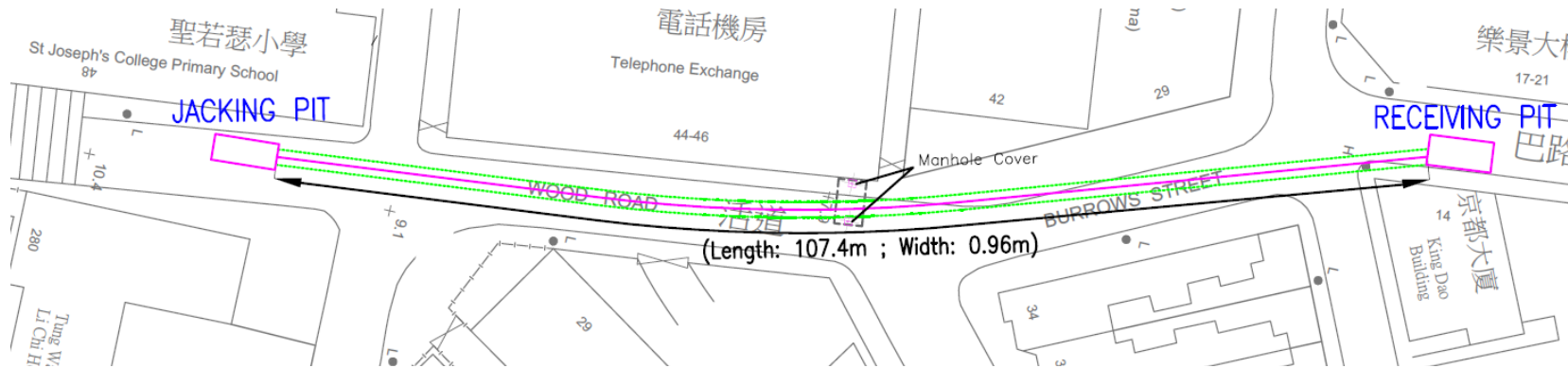
AVN 800 HR, Hong Kong

REFERENCE PROJECT HARD ROCK MICROTUNNELLING

- › M-2496M, AVN 800 HR, OD 975 mm
- › Location: Wan Chai, Hong Kong
- › Project: installation of water main
- › Drive length: 107 m
- › Curve radius: 153 m
- › Geology: rock grade II, granite
 - › UCS up to 200 MPa
- › Duration: 60 working days
- › Client: Water Supplies Department of Hong Kong
- › Contractor: VTEC



REFERENCE PROJECT HARD ROCK MICROTUNNELLING



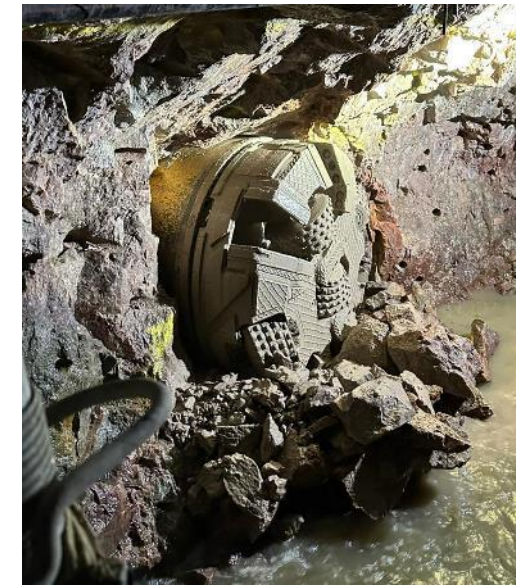
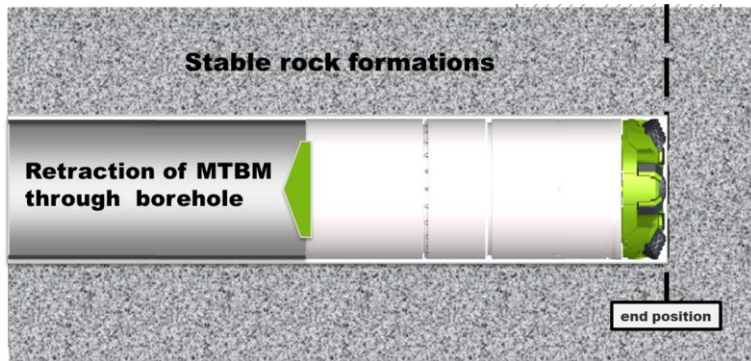
Utility Tunnelling

EDSBERG, SWEDEN AVN 800 FOR HARD ROCK

- › Drive length: 163 m
- › Geology: Granite, Gneiss
- › Compressive Strength (UCS): 128 bis max. 248 MPa, σ_c 174 MPa
- › Abrasivity (CAI): 4.1 – 4.7 / σ_c 4,5
- › Performance: 10 – 25 mm/min
- › Blind Hole Drilling / Retractable Machine & Pipe
- › Stable borehole = 0 cement consumption



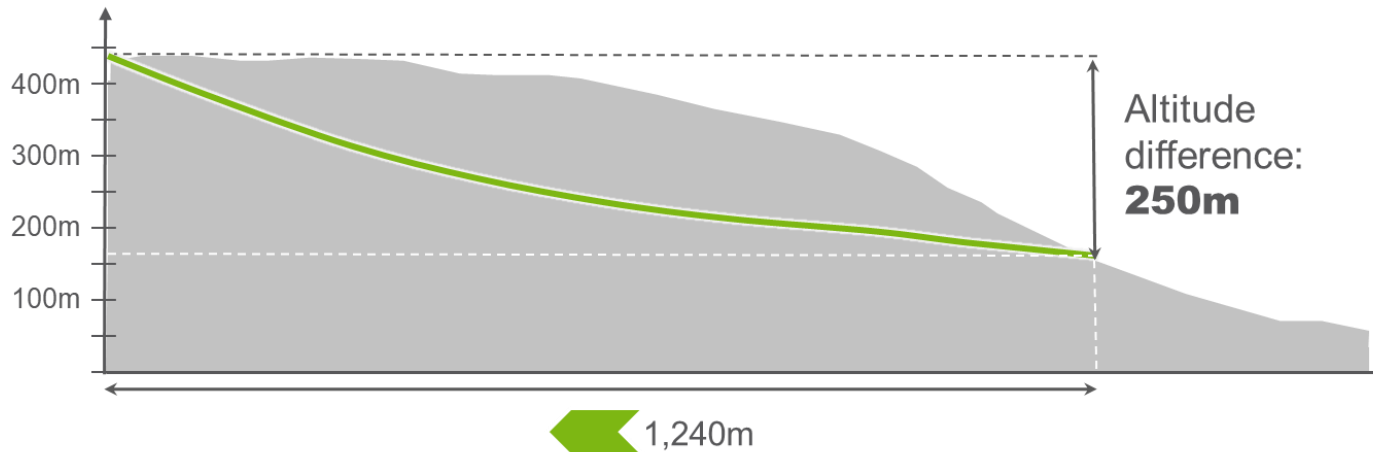
HERRENKNECHT.CONNECTED



Hydropower Project | Reinaa Hydro Electric Powerplant, Meraker, Norway

SMART ALTERNATIVE FOR SMALLER DIAMETERS | HDD UPHILL

- › H-332, HK250C
- › Drilling length: 1,244 m
- › Water Pipeline Ø: 32" / 813 mm, max. 24° slope
- › Drilling Ø: 978mm
- › Geology: hard rock > 200 MPa
- › Contractor: Hywer AS & Norsk Retningsboring AS



Hydropower Project | Reinaa Hydro Electric Powerplant, Meraker, Norway

SMART ALTERNATIVE FOR SMALLER DIAMETERS | HDD UPHILL



H-332

MONGSTAD, NORWAY. LANDFALL OF A GAS PIPELINE IN NORWAY

DRILLING IN ROCK FOR LANDFALL – PIPELINE WITH 45° INCLINATION.



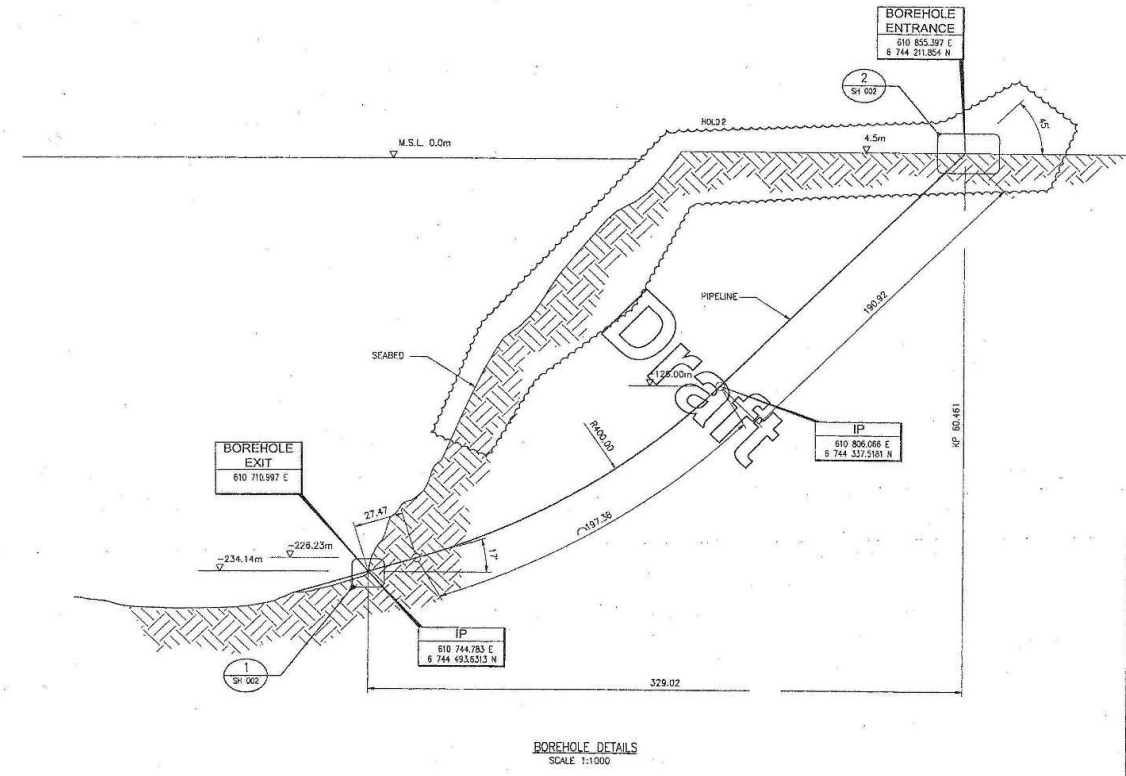
Mongstad | Norway

- › Machine: HK250T
- › Geology: Hard rock, up to 276 MPa
- › Drilling Length: 416m
- › Pipeline-Ø: 14"
- › Medium: Gas
- › Entry Angle: 45°
- › Exit point: 234 m below sea level
- › Contractor: Visser & Smit Hanab

MONGSTAD, NORWAY. LANDFALL OF A GAS PIPELINE IN NORWAY.



- ▶ Exit point, 234m below sea level



- ▶ side view of the drilling profile
- ▶ $L = 416\text{m}$, $\Delta H = 234\text{m}$

HYBRID HDD RIG | HK80CK

- › Compact crawler rig with electric engine
- › Small footprint for jobsites in urban areas
- › all components can be mounted directly on the rig
- › Low in emissions and noise



HYBRID RIG HK80CK

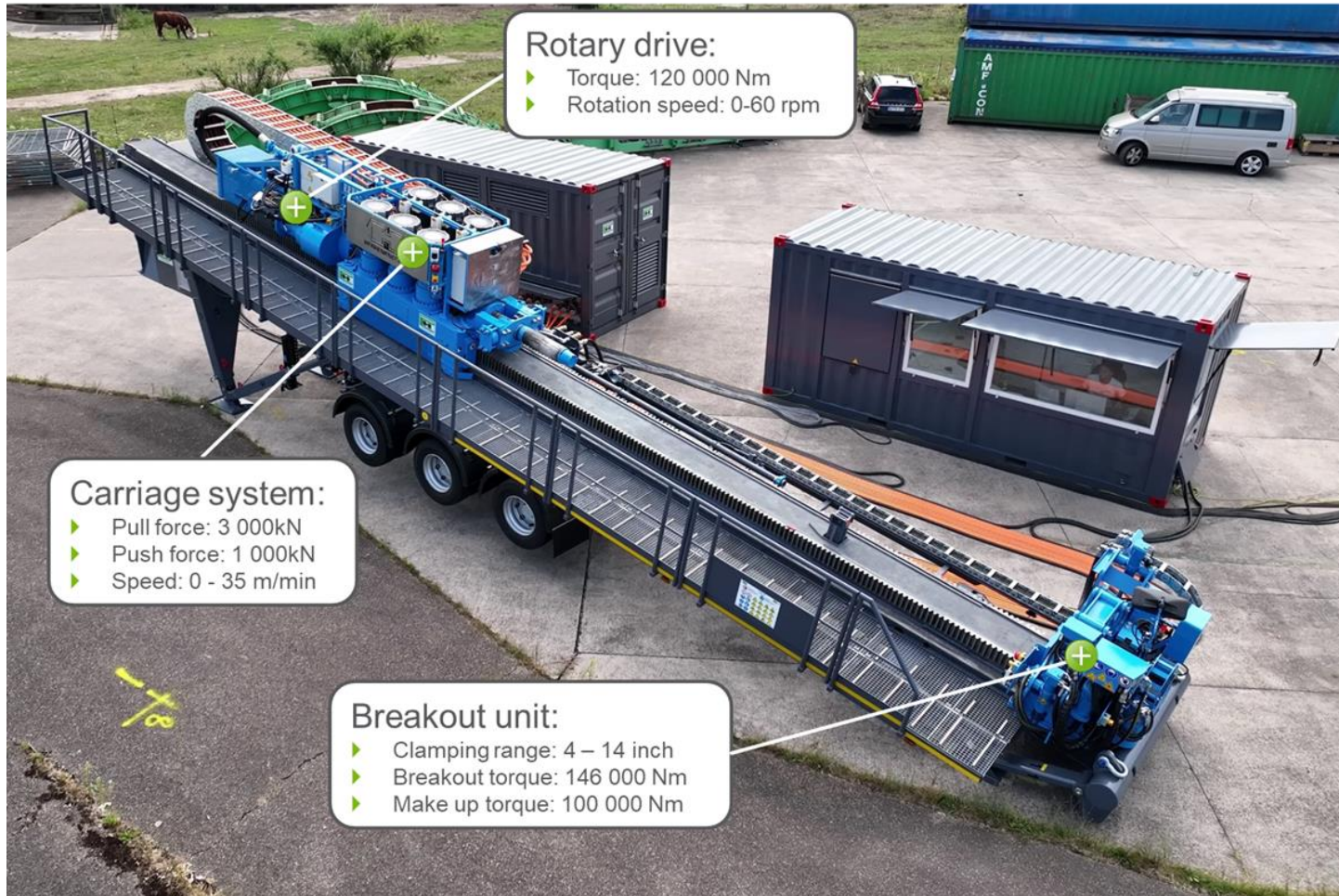
Rig

- › Installed power: 324 kW (434 hp)
- › Power transmission: Rack & Pinion
- › Drilling angle: 9°–21°
- › Drill pipe length: 6,000 mm (20 ft)
- › Pipe support system on mast: 2



60.000Nm / 80 up to 120to pulling force / 0-80rpm, installed installed: L= 1120m / Ø610mm pipe

ALL-ELECTRIC HDD RIG | HK300TE



CO2-Emissions



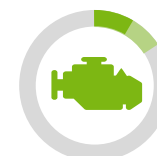
Fuel Consumption



Noise Emissions



Maintenance



Reduced leakage

SMART GENERATORS FOR OPERATION OF ELECTRIC RIG (HK300TE)



500 kVA



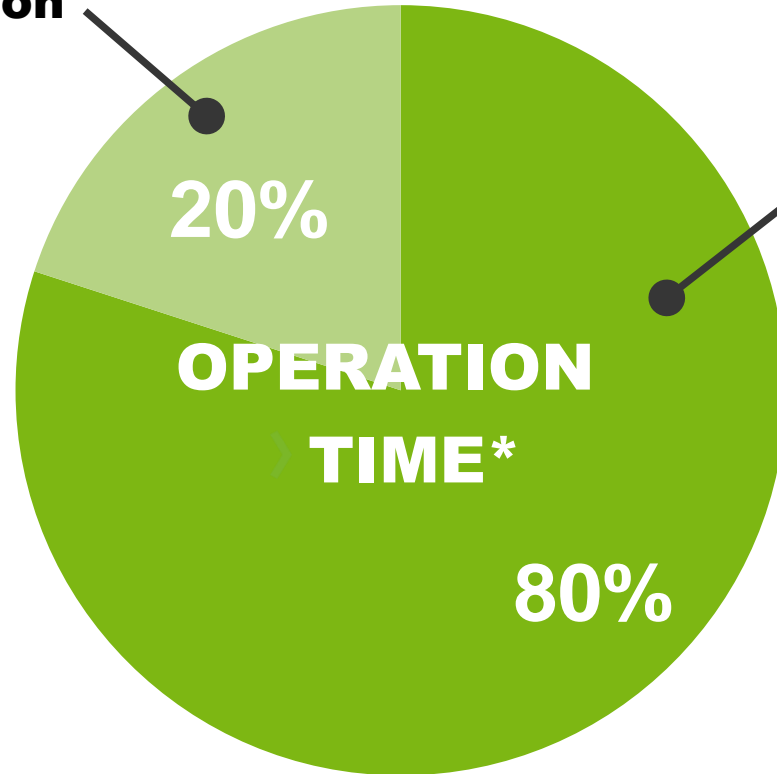
> **PEAK** Operation



250 kVA



250 kVA



> **REGULAR** Operation



250 kVA



250 kVA

> **30-40%*** **REDUCTION** of **FUEL** consumption

* rough estimation

HDD Portfolio

ALL-ELECTRIC HDD RIG HK45CKE

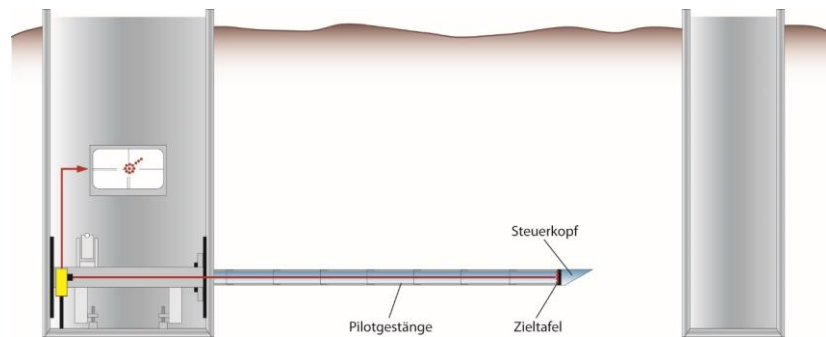


GUIDED AUGER BORING

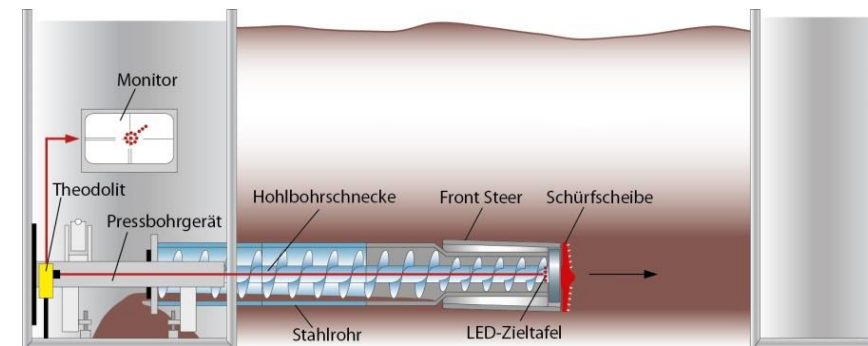
Different solutions for different ground conditions



Auger boring with ground displacement in first step

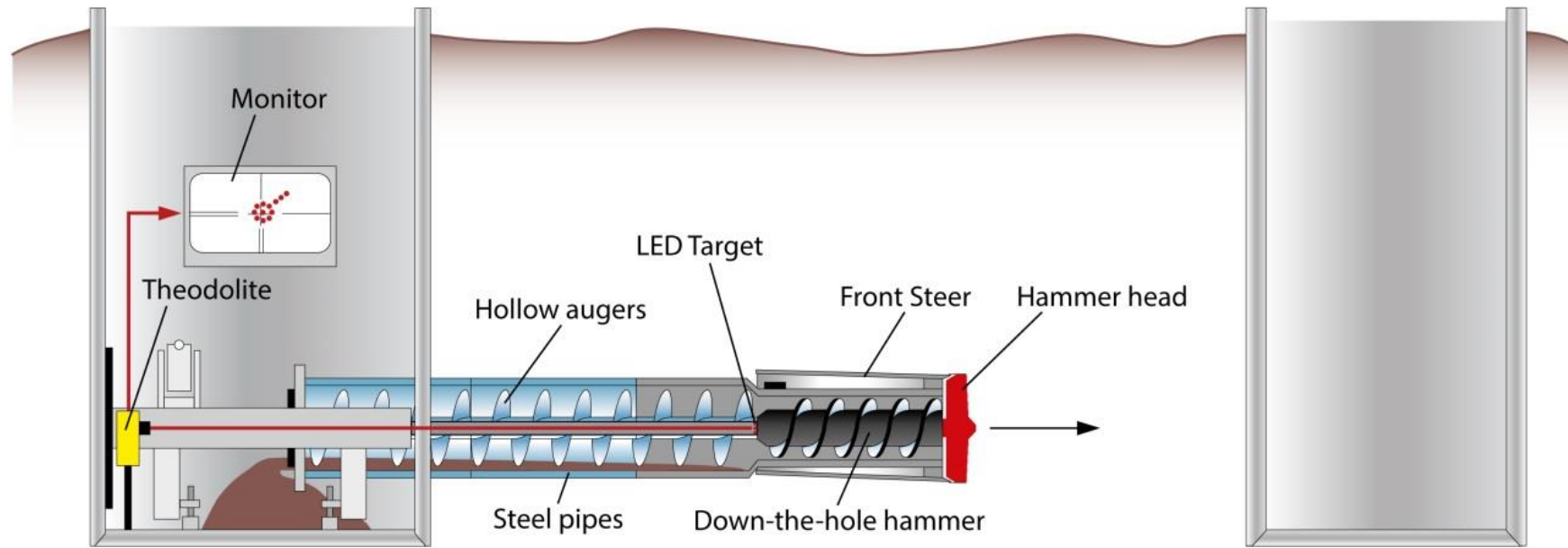


Auger boring with ground removal in first step



Guided auger boring with ground removal

Front Steer for rock up to 250 MPa

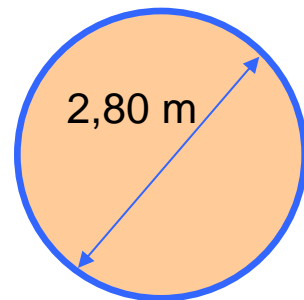


Smallest possible OD = 324 mm

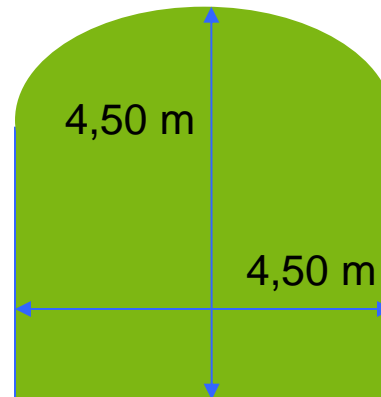


ADVANTAGES OF TBM COMPARED TO D+B EXCAVATED VOLUME, MINIMUM DIAMETER

- Especially when a small diameter or small section is required a TBM is more effective:
- Example: a final diameter of 2,8 m is required to install two pipelines with ID1200
- in ratio: 3,25 x times more excavated volume, costs...



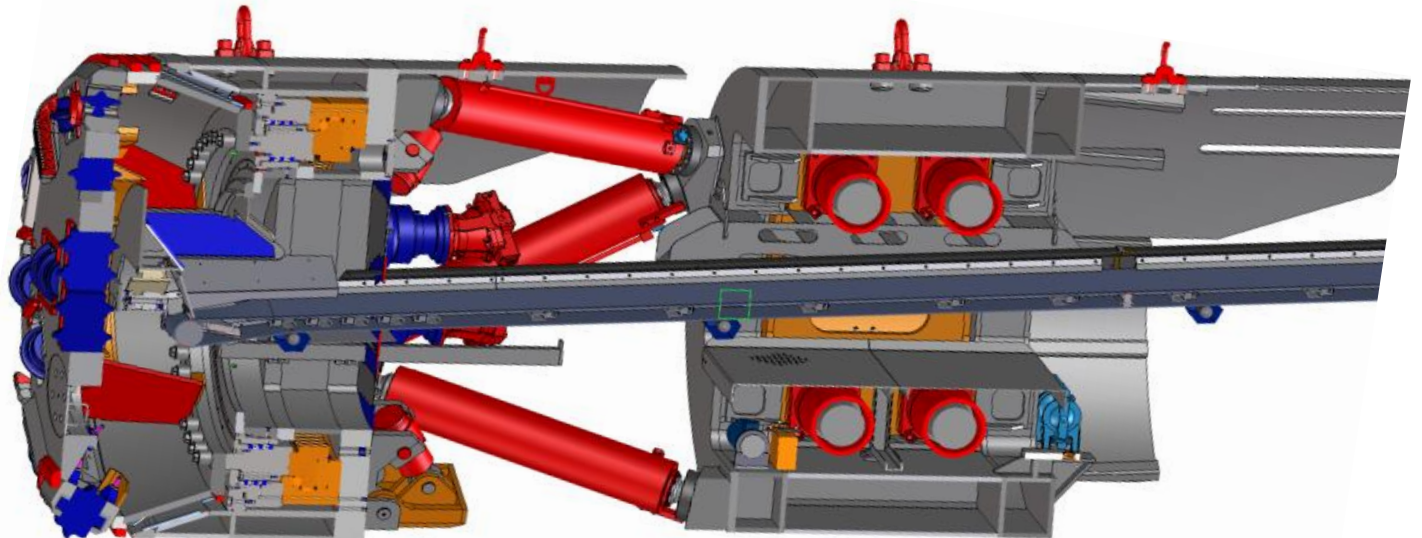
TBM -
excavated
volume:
6,15m²



D&B:
minimum
excavated
volume: 20m²

MICRO GRIPPER TBM. MAIN CHARACTERISTICS.

- Suitable for stable rock
- Temporary lining: roof bolting, mesh & beam
- Min. cutting diameter: 2580mm
- Production : 250-500m/month
- Compact design
- Suitable for tight curves(~150m)



Micro Gripper TBM.

Reference Project: Rio Vermelho HEPP.

- ▶ M-1848M, Gripper TBM 2850 retractable
- ▶ Location: Sao Bento do Sur, Brazil
- ▶ Use of tunnel: Water tunnel for Mini-HEPP Project
- ▶ Tunnel length: 7.7km in 6 drives
- ▶ Longest drive: 3.000m
- ▶ TBM retraction through tunnel
- ▶ Geology: stable rock
- ▶ No shotcrete, no cement consumption
- ▶ Well suitable for stable hard rock
- ▶ Compact machines for small HEPP
- ▶ Small curves Min. R = 150m
- ▶ 14" discs – max. UCS ~ 350 MPa
- ▶ First 2 Multi-Service-Vehicles in use for Utility Tunnelling machine
 - ▶ Most “slim” version of MSV ever built



Project Reference Switzerland

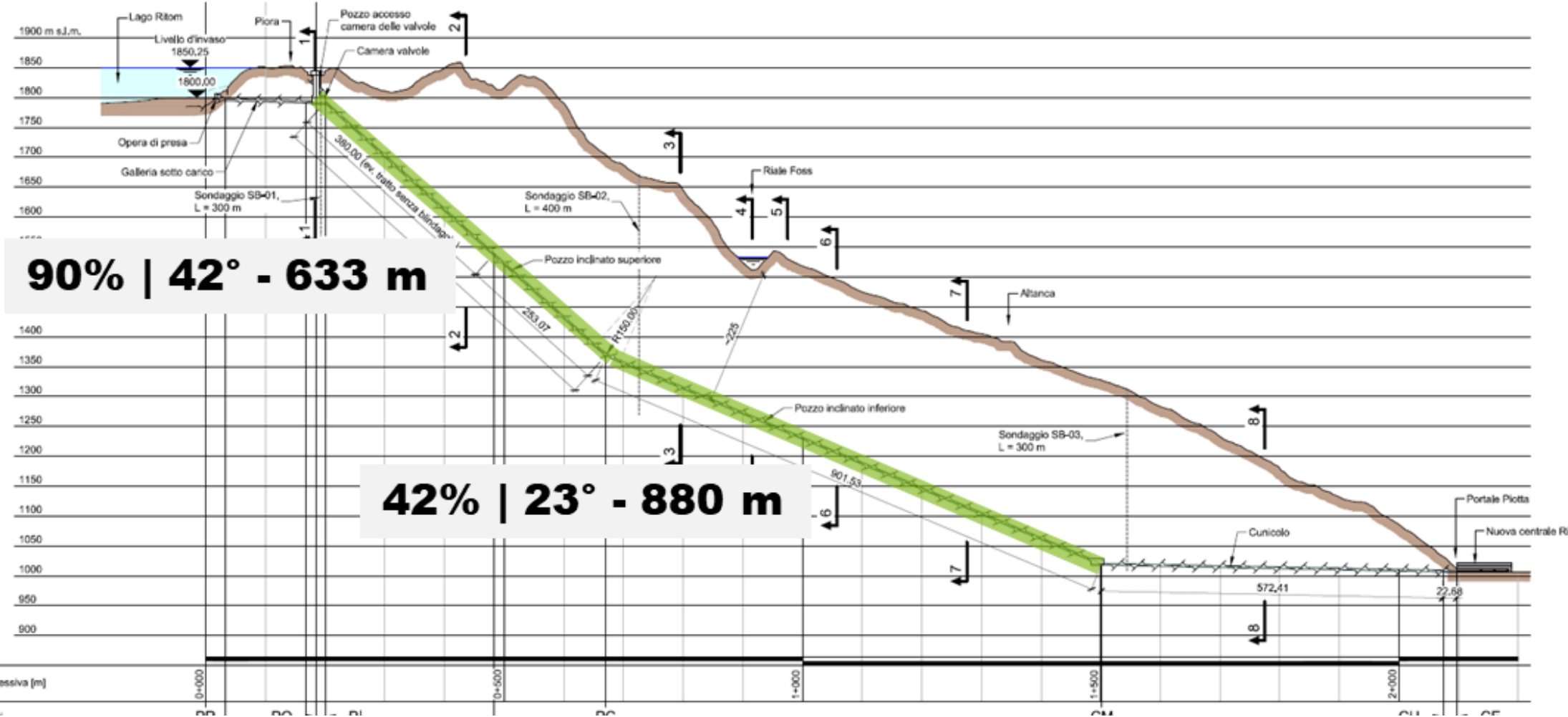
POWER PLANT RITOM GRIPPER-TBM

- › M-2378M, Gripper TBM, OD 3230 mm
- › Location: Piotta, CH
- › Tunnel length: 1,513 m
 - › 880 m (42% / 23° slope)
 - › 633 m (90% / 42° slope)
- › Geology: Ortho- and paragneiss (80–200 MPa), two-mica-shist and paragneiss (10 – 80 MPa)
- › Min. curve radius: 150 m vertical
- › Best daily performance 25 m
- › Contractor: Marti Tunnel AG, Mancini & Marti SA and Ennio Ferrari SA
- › Client: SBB CFF FFS und AET



Project Reference Switzerland

POWER PLANT RITOM GRIPPER-TBM



Hardrock-hightech for Norway

ULRIKENTUNNEL

- › Double track tunnel along the Norwegian Bergen Line
- › 1x Gripper-TBM | Ø 9,300mm
- › Tunnel length: 6,725m
- › Final breakthrough: 08/2017



Hydro-Electric Power Projects

TBM TYPES FOR ROCK CONDITIONS

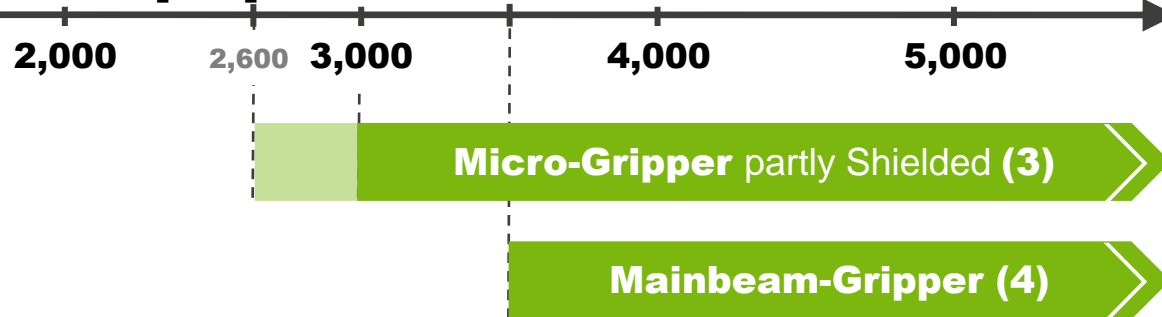
SHIELDED TBMs

Tunnel Inner Diameter [mm]



NON/PARTLY SHIELDED TBMs

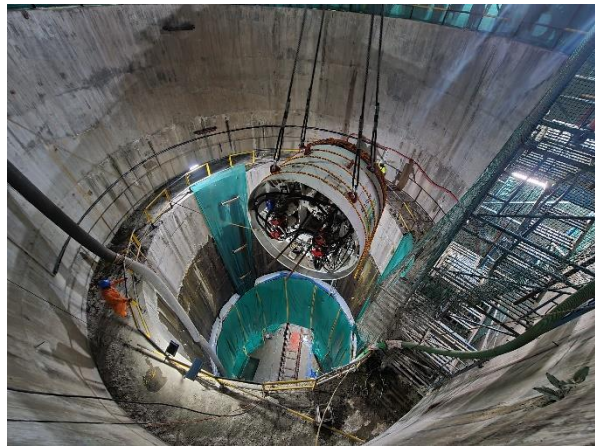
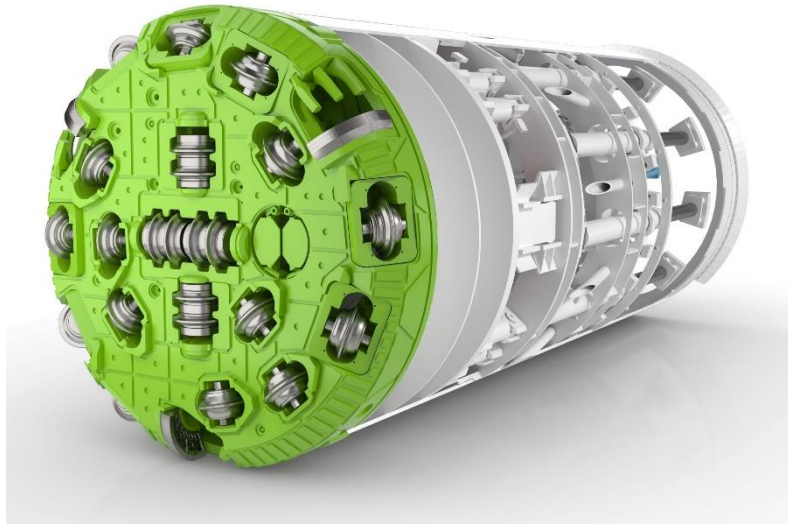
Excavation Diameter [mm]



Reference Project **Single Shield TBM**

SURYA REGIONAL BULK WATER SUPPLY SCHEME | MUMBAI, INDIA

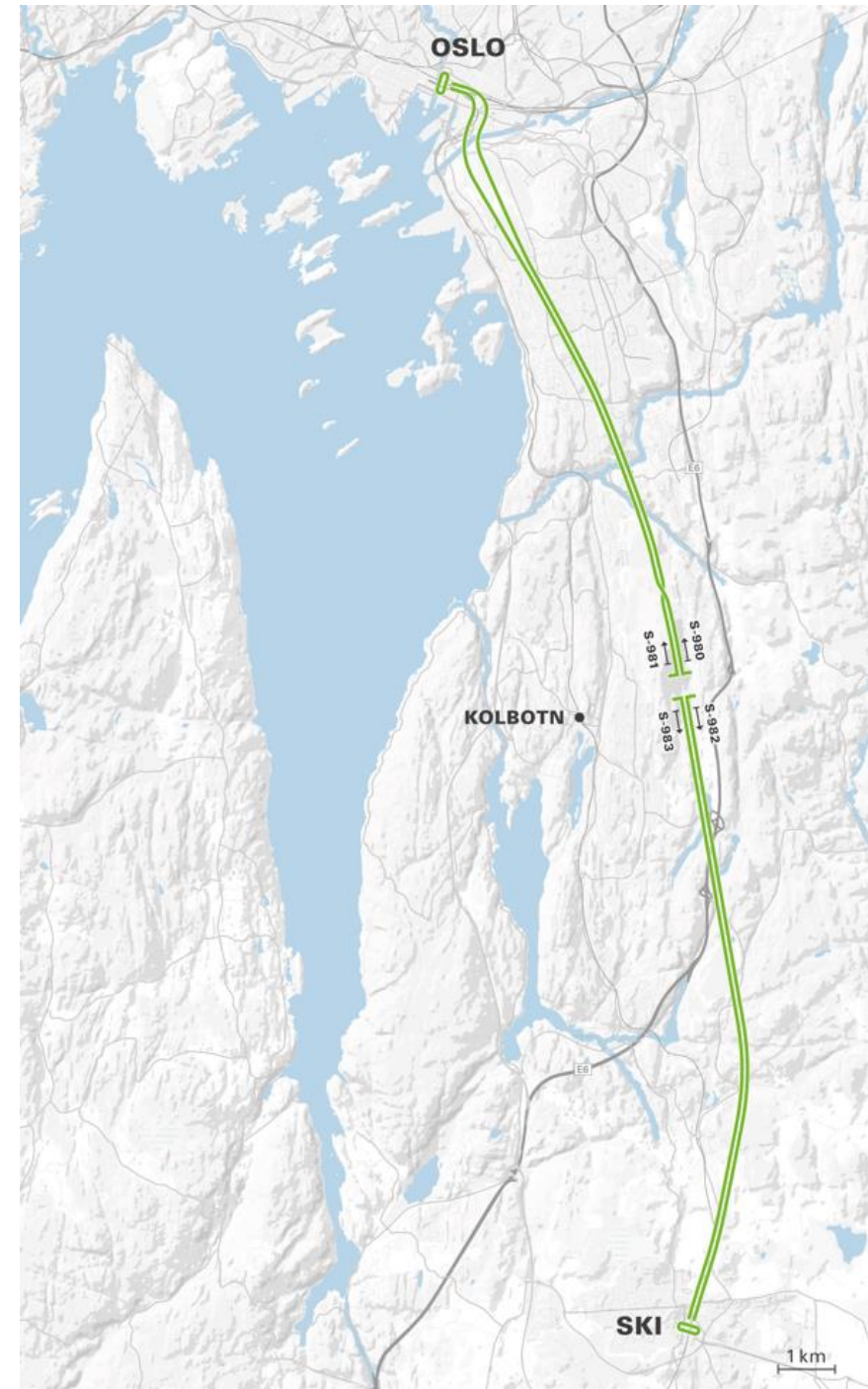
- › M-2309M, TBM 2850 XH, OD 3625 mm
- › Segment ID 2850 mm | OD 3450 mm
- › Tunnel length: 6,326 m (1,170 + 4,610 m)
- › Ground conditions: basalt, max. 150 MPa
- › Contractor: Larsen & Toubro (L&T)
- › Best daily performance: 21 m
- › Best weekly performance: 109 m



Norway's largest infrastructure project

FOLLO LINE OSLO

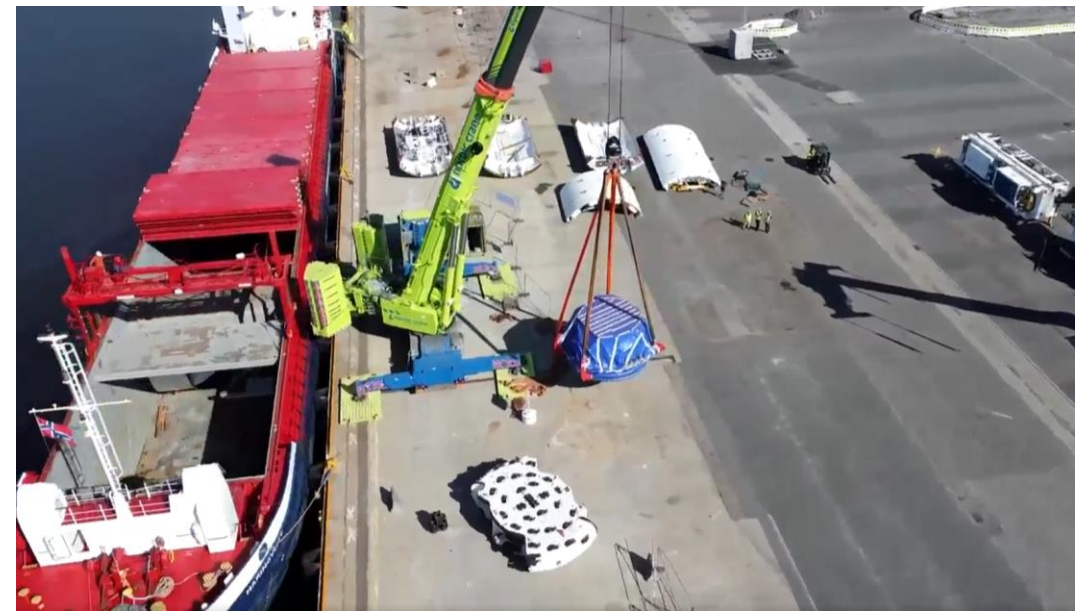
- › 38 km railroad tunnel between Oslo and Ski
- › Reduction of travel time by 50%
- › **4x double shield** technology for rapid advance in stable rock
- › Best advance rates: 550 m/month
- › First major project in Norway with mechanized tunnelling technology
- › Final double breakthrough February 2019



Water supply

NEW WATER OSLO RAW WATER TUNNEL

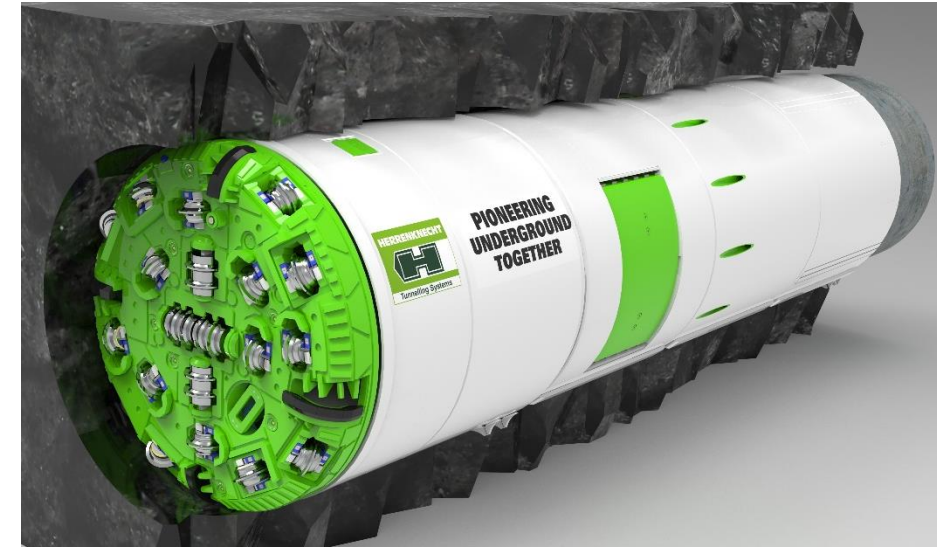
- › The Oslo New Water Supply Project aims to provide the capital's residents with a reliable backup water supply
- › 3x Double Shield TBM, 2x Ø 5,150mm, 1x Ø 7,020mm
- › Tunnel length: 30,000m
- › S-1320, S-1321 started in 2023 for Lot E05 (19km)
- › S-1349 for Lot E06 followed in 2024



Reference Project Double Shield TBM

INTER-RESERVOIRS TRANSFER SCHEME (IRTS) | HONG KONG

- › M-2500M, Double Shield TBM, Shield OD 3675 mm
- › Segment ID 3000 mm | OD 3450 mm | L1200 mm
- › Tunnel length: 2,800 m
- › Ground conditions: hard rock, granite
- › Gradient: 0,665% | Min. Radius: 250 m
- › Contractor: Bouygues/Dragages



Hydro-Electric Power Projects

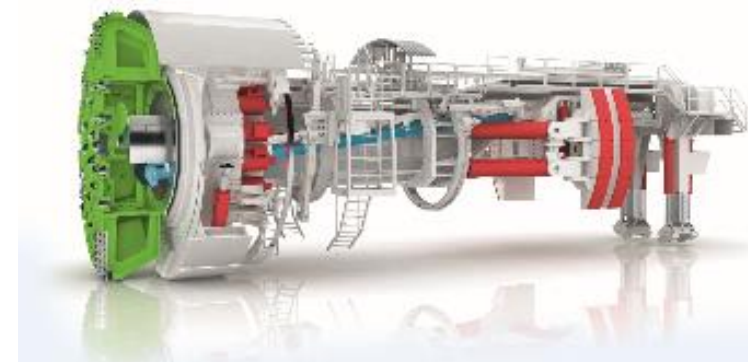
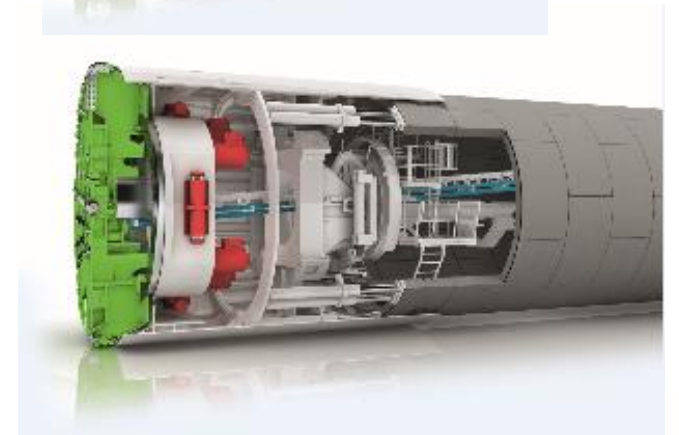
CONSTRUCTION METHODS: DRILL & BLAST VS. TUNNELLING WITH TBM.

General cost advantages of TBM technology

- › Higher investment, but lower operating costs
- › Less personnel required for operation and maintenance
- › **Excavation of required diameter, saves disposal / volume of excavated material, smaller diameters, less volume of excavated material, less transport & emission**

General time Advantage of TBM technology

- › TBM provides continuous tunnel advance
- › higher advance rates per day
- › More reliable project planning
- › as machine design and lining minimizes risk arising from changing geological conditions



Hydro-Electric Power Projects

CONSTRUCTION METHODS: DRILL & BLAST VS. TUNNELLING WITH TBM.

General Advantages of TBM technology

- › **Flexibility:** Tunnel boring machines are capable of working through any rock and also under water pressure and through “hydraulic soils” at any depth
- › **Safety:** Increased safety for employees due to controlled excavation
- › **Impact:** less noise, less disturbance of the surrounding environment, buildings and infrastructure
- › **Clean:** Less emission inside and outside the tunnel
- › **Recycling:** Uniformly excavated material can be reused

LUTZ ZUR LINDE

Sales Manager Business Unit Utility Tunnelling

Telefon: +49 175 547 30 13

Mail: zurlinde.lutz@herrenknecht.com



Herrenknecht AG

Schlehenweg 2

77963 Schwanau

Deutschland

